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# R&D and Capital Markets

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Economic growth and the consequent welfare improvement of nations and individuals are driven mainly by *technological change*, as manifested by the introduction of new products and services, the development of more efficient systems of production, and improvements in the organization and management of commerce and industry. Research and development is the major driver of technological change—hence the central role of R&D in economic growth and welfare improvement. The impact of R&D and technological change on economic growth has long been recognized by proponents of free market economies such as Adam Smith, Marshall, Keynes, and Solow. Even two of the most ardent critics of capitalist societies, Marx and Engels, argued in the Communist Manifesto that capitalism depends for its very existence on the constant introduction of new products and processes.

This sequence of effects—from R&D to technological change to increases in productivity and growth—holds not only for nations, but for individual companies and business units as well. A large and growing number of empirical studies have confirmed a significantly positive association between national, industry, and corporate R&D expenditures, on the one hand, and economic growth, productivity gains, and increases in corporate earnings and market values.[1]

The growth of R&D expenditures over the last two or three decades, together with the continuous substitution of knowledge (intangible) capital for physical (tangible) capital in firms' production functions, has elevated the importance of R&D in the performance of business enterprises. The ability to evaluate the risk and eventual payoffs from corporate R&D is therefore of considerable importance to capital market practitioners and researchers. The evaluation of R&D activities is seriously impeded, however, by antiquated accounting rules and insufficient disclosure by corporations. Despite the obvious benefits of R&D, which generally stretch over extended periods of time, this investment is immediately expensed (written off) in corporate financial reports, leaving no trace of R&D capital on firms' balance sheets and causing material distortions of reported profitability.[2] Immediate expensing is practiced not only for internally generated R&D, but also in the growing number of acquisitions involving large amounts of "R&D-in-process," further distorting reported performance.[3]

The fact that only scant information on R&D and other innovative activities is publicly disclosed by firms compounds the information problems of investors when evaluating high-tech companies. Investors are generally told little about the nature of firms' research activities, such as the share of total R&D devoted to basic research, new product development, or efforts to increase the efficiency of production processes (known as "process R&D"). Nor is information typically furnished about the expected benefits and duration of products under development. Even the total R&D expense reported in corporate income statements often misrepresents the extent of activities aimed at producing innovations, particularly for small companies that do not formally classify such activities as R&D.

Given the importance of corporate research activities to capital market practitioners and researchers, and the inadequacy of public information on R&D, I provide in this essay:

- salient statistics about recent trends in corporate R&D;
- a brief summary of international disclosure regulations;
- a survey of the major empirical findings concerning R&D and its benefits, particularly as reflected in capital markets; and
- some guidelines for investors and analysts engaged in the valuation of R&D-intensive enterprises.

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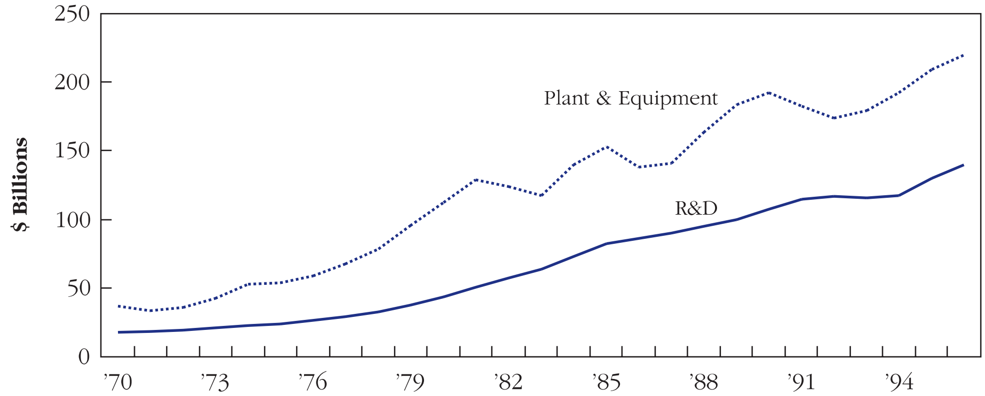
1. See, for example, Griliches 1995, Hall 1993a, Lev and Sougiannis 1996, Coe and Helpman 1995. Full citations for all studies cited in the text and notes of this paper appear in the References section at the end of the article.

2. The most obvious effect of this accounting practice is to reduce current earnings for companies with high R&D growth. But, as discussed later in this paper, a more subtle distortion is the tendency to *inflate* popular return-on-investment measures like ROE and ROA.

3. Deng and Lev (1998).

**FIGURE 1**
ANNUAL EXPENDITURES OF MANUFACTURING FIRMS ON NEW PLANT AND EQUIPMENT AND ON R&D




Sources: Economic Report of President, 1997 for investment in new plant and equipment, and National Science Foundation/SRS for R&D.

## RECENT TRENDS IN R&D

Total annual R&D expenditures in the U.S. increased from $26 billion in 1970 to $206 billion in 1997, representing an average yearly growth rate of 8.0%, while investment in plant and equipment over the corresponding period increased annually by 6.8%, on average.[4] By comparison, the aggregate growth rate of R&D in the European Union countries during 1991-1996 was about half the U.S. rate. Of the $206 billion devoted to R&D in the the U.S. in 1997, $151 billion (or 73.3% of the total) was industry R&D, while the rest was sponsored by the federal government ($16.5 billion, or 8.0%), universities ($27 billion, 13.1%), and other institutions (5.6%).

Some perspective on the relative magnitude of industry R&D is provided by Figure 1, which portrays the relationship over the last 25 years between total annual expenditures of U.S. manufacturing firms on new plant and equipment (tangible investment) and their expenditures on R&D. While investment in plant and equipment has been very volatile, exhibiting sensitivity to economic conditions (particularly the recessions of the early 1980s and 1990s, which led to *decreases* in plant & equipment investment), expenditures on R&D have increased smoothly due to the constantly expanding opportunities in emerging technologies, such as biotech, computers, and telecommunications.

Besides increasing steadily in absolute terms, corporate investment in R&D has also increased relative to the scale of firms' operations. Figure 2 presents the annual average "R&D intensity" (that is, R&D as a percentage of revenues) of Compustat companies that report R&D (upper curve) and of all Compustat companies (lower curve). As shown in the upper line of Figure 2, for the former group, R&D expenditures as a percentage of revenues more than doubled from 1.9%, on average, in 1978 to 4.0% percent in 1997.[5] And the R&D intensities of high-tech, science-based companies have been substantially higher than the overall averages shown in Figure 2. For example, in 1996 the average R&D intensities of electronics, drugs, software, and biotech companies were, respectively, 6.1%, 12.0%, 17.8%, and 41.0%.[6]

Structural changes that occurred in the U.S. economy during the 1980s and early 1990s helped to increase the relative role of R&D in publicly traded companies. The increased focus of manufacturing firms on core operations accomplished by restructurings and spinoffs had the economy-wide effect of moving capital out of low-R&D sectors, such as chemicals, metals, and machinery, and into the high-tech sectors of pharmaceuticals, biotech, software and electronics.[7] The R&D intensity of the public-company sector increased further because the firms that went private through LBOs or were

4. The statistical data in this section are derived from the Economic Report of the President, 1997; the National Science Foundation/SRS; and the OEDC publication : Main Science and Technology Indicators, 1998.

5. The increase of R&D intensity is not due to increases in R&D input prices, rather to enhanced R&D activities of corporations (see Scherer, 1992, p. 1428)

6. Computed from Compustat, for SIC codes: 3600-3699, 2834, 2836, and 7372.

7. Hall (1993a).

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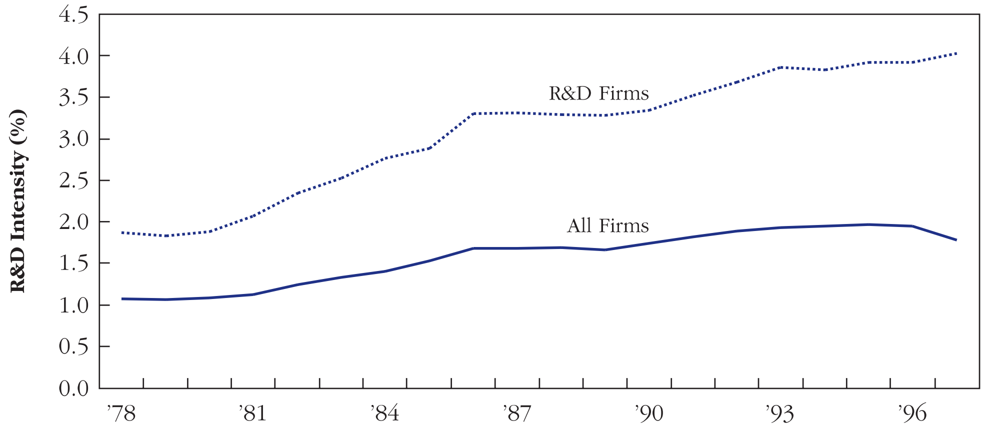
**FIGURE 2**
AVERAGE R&D INTENSITY (R&D OVER REVENUES) OF FIRMS HAVING R&D AND ALL FIRMS




Source: Compustat.

acquired by foreign companies during the 1980s tended to be low in R&D (such as food companies and retailers). At the same time, the majority of the new entrants to capital markets in the 1980s and 1990s were high-tech firms traded on the NASDAQ.

## Disclosure Regulations

Disclosure requirements in corporate financial reports for *internally generated* R&D vary across countries.[8] The main differences concern the income statement and balance sheet treatment of R&D. Public companies in the U.S. are required to expense all R&D outlays as incurred.[9] German companies also generally expense all R&D outlays, to conform to tax regulations. But most other developed countries allow—and, under certain circumstances, require—the capitalization (i.e., recognition as an asset) and subsequent amortization of certain R&D outlays, particularly identifiable product costs. For example, in the U.K., Canada, France, Australia, the Netherlands, Israel, and Sweden, public companies may capitalize the costs of development (but generally not basic research) when the projects under development are clearly defined and the expenditures separately identifiable. Japanese companies may capitalize R&D, but have to amortize it within five years. The amortization of the R&D capital is determined by the expected useful life of the projects.

Most countries require disclosure in the financial reports of the amounts of R&D expensed or capitalized, typically in footnotes. Moreover, in September 1998, the International Accounting Standards Committee (IASC) issued Standard No.38 on Intangible Assets, which calls for the capitalization of R&D costs for projects that meet certain criteria. Most important are that the projects (1) be clearly identified (i.e., costs and expected revenues are clearly separable from general corporate R&D), (2) have passed a technological feasibility test, and (3) be shown capable of recovering the capitalized costs.

In recent years, an increasing number of firms have been *purchasing* "R&D-in-process" (i.e., still incomplete projects and processes), generally through a corporate acquisition. Here, too, U.S. reporting standards are less flexible than those of most other countries. In the U.S., the purchasing companies are required to write off immediately the entire value of the acquired R&D-in-process. In contrast, the U.K., Canada, Australia, and New Zealand, as well as countries that have adopted the international standard, allow the capitalization of acquired R&D, which then must be amortized over its expected useful life.

As should be evident from this brief international survey, the required public disclosure of R&D activities by U.S. companies—essentially a single line item in the income statement—is wholly inad-

8. Information on international R&D disclosure regulations was obtained from Coopers & Lybrand (1993).

9. The only major exception in the U.S. to the immediate expensing of R&D are software development costs (FASB Statement No. 86) which have to be capitalized when a product passes successfully a technological feasibility test. Prefeasibility development costs are expensed as incurred.

equate for the purpose of financial and security analysis. Reported profitability is seriously distorted; sometimes understated, often overstated. And the absence of R&D capital from financial reports denies investors the ability to assess the firm's return on innovative activities.

## THE EMPIRICAL RECORD

Systematic economic research on the relationship between R&D and the attributes of firms and the markets in which they operate was initially motivated by Joseph Schumpeter's (1942) hypothesis that large and monopolistic companies have significant advantages in conducting research and developing products, mainly due to their sustained profitability and access to relatively inexpensive capital. Extensive empirical research, however, failed to substantiate a reliable association between either input or output measures of R&D and individual company or market attributes, such as size or the extent of competition in the product market.[10] In fact, the success of many small software, electronics, biotech, and pharmaceutical companies in conducting R&D and marketing products within highly competitive environments clearly runs counter to Schumpeter's hypothesis.

### Research on R&D and Productivity

From examining industrial organization and market structure issues, mainstream economic analysis of R&D largely shifted in the 1970s to investigating the social and private returns to investment in R&D. This empirical work, which started with extensive historical case studies and proceeded to large-sample cross-sectional analyses of the impact of R&D on productivity and growth, was aimed mainly at assessing the consequences of R&D investment and addressing public concerns such as the role of R&D in the protracted productivity slowdown in the U.S. in the 1970s and early 1980s.[11]

This research effort yielded several important findings:[12]

- R&D expenditures contribute significantly to the productivity (value added) and output of firms, and the estimated rates of return on R&D investment are quite high—as much as 20-30% annually—although varying widely across industries and over time.[13] Indeed, the estimated returns to R&D are more than double the returns to tangible capital, reflecting the higher productivity as well as riskiness of R&D capital relative to physical assets.
- The contribution of *basic* research—research aimed at developing new science and technology—to corporate productivity and growth is substantially larger than the contribution of other types of R&D, such as product development and process R&D. In fact, the estimated contribution differential is about 3-to-1 in favor of basic research[14]—a finding that is particularly intriguing, given the widespread belief that firms have been recently curtailing expenditures on basic research and the skepticism expressed by many financial analysts and institutional investors about basic research.[15] Basic research is, of course, more risky than applied R&D, but it is inconceivable that risk differentials account for a 3-to-1 productivity superiority of basic research.
- The contribution of privately financed corporate R&D to productivity growth is larger than that of corporate R&D that is financed by the government (granted primarily to government contractors). The fact that most contracts with the government are based on "cost plus" terms may partly explain this finding. Nevertheless, the contribution to the technological infrastructure of industry of government-funded research conducted by government agencies and in federal laboratories (such as, for example, the National Institute of Health) as well as university research is very significant.[16]

10. For surveys of this research, see Cohen and Levine (1989) and Scherer (1992).
11. See, for example, Lichtenberg and Siegel (1991).
12. For a discussion of these findings and the methodological issues involved in analyzing the cost-benefit relationship of R&D, see Griliches (1995).
13. See Hall (1993a); and for estimates of returns on tangible capital, see Poterba (1997). Documenting a positive contribution of R&D to productivity and growth is hardly surprising; why else would managers invest so heavily in R&D? Yet, this finding stands in stark contrast to a major assertion underlying the Financial Accounting Standards Board's (FASB) requirement for the immediate expensing of R&D in financial reports: "A direct relationship between research and development costs and specific future revenue generally has not been demonstrated, even with the benefit of hindsight." (FASB, 1974, p. 14).
14. See Griliches (1995). Related findings concern the importance of university research to industrial innovation (e.g., Mansfield 1991, Acs et al. 1994).
15. First-hand evidence of adverse analyst attitudes towards basic research can be found in an article by Richard Mahoney, former chairman and CEO of the Monsanto Company, describing how Monsanto developed over an extended period its biotechnology capacity, while analysts "naysayers offered a constant drumbeat of advice: reduce R&D, sell off any asset that wasn't nailed down and use the cash proceeds to buy back shares." (*The New York Times*, May 31, 1998).
16. See Mansfield (1991). Striking examples of major contributions of government R&D to industry are the Internet, funded originally by the Department of Defense as a bomb-resistant communicvations network, and later developed by the National Science Foundation, and the Human Genome Project, initiated by the National Institute of Health, now leading to revolutionary advances in biomedicine.

**Despite widespread allegations of stock market "short termism" throughout the 1980s and early '90s, the research indicates persuasively that capital markets consider investments in R&D as a significant value-increasing activity.**

■ The gap between the private and social benefits of R&D is wide. R&D "spillovers"—that is, benefits to one firm (industry or nation) from another firm's (industry or nation's) R&D or pool of knowledge—are substantial. Consequently, the "social" rate of return on R&D is considerably higher than the return to individual firms.[17] This finding generated extensive analysis of the adequacy of corporate incentives to conduct R&D, and the optimal design of arrangements for appropriating R&D benefits (e.g., patents, trademarks).

Because of the scarcity and other shortcomings of information *published* by individual companies, the research findings outlined above were based primarily on survey data and industry aggregates. In fact, none of the examined variables and attributes—return on R&D capital, basic vs. applied research, company vs. government sponsored R&D, and private vs. social benefits of R&D—can be directly estimated for individual companies from information publicly disclosed to investors. Thus, one of the most promising uses of the above findings is to suggest the kinds of information and data that investors should seek from R&D-intensive companies and that companies should consider disclosing to investors.

## Research on R&D and Capital Markets

The research effort surveyed above related R&D inputs (intensity, capital) to firms' productivity, sales, or profit growth in an attempt to estimate the return on corporate investments in innovation-producing activities. But this approach encounters various problems. Perhaps most obvious, the time lag between the investment in R&D and the realization of benefits is generally unknown and often long (particularly for basic research), increasing the uncertainty about the estimated regression parameters. Furthermore, biases and distortions in reported profits (such as those arising from "opportunistic" decisions by managers to cut back or expand R&D to "smooth" reported income) may cloud the intrinsic relationship between the cost of R&D and its benefits.

Such measurement difficulties have prompted a search for alternative and more reliable indicators of R&D *output* than conventional profitability measures. Two measures have received considerable attention—patents and capital market values—and they are discussed in the following review of the growing number of studies examining the relation between R&D and market values.[18]

**Investors' Recognition of R&D Value.** Despite widespread allegations of stock market "short termism" throughout the 1980s and early '90s, the research indicates persuasively that capital markets consider investments in R&D as a significant value-increasing activity. Thus, for example, a number of "event studies" register a significantly positive investor reaction to corporate announcements of new R&D initiatives, particularly of firms belonging to high-tech sectors and operating on the cutting edge of technology.[19] Moreover, when information is available, investors distinguish among different stages of the R&D process, such as program initiation and commercialization, rewarding in particular mature R&D projects that are close to commercialization.[20] Furthermore, econometric studies that relate corporate market values or market-to-book ratios to R&D intensities consistently yield positive and statistically significant association estimates.[21] Further probing into such associations suggests that firm size affects the valuation of R&D in the sense that investors value a dollar R&D spent by large firms more highly than R&D of small firms, perhaps due to better information available on large firms.[22] The evidence thus indicates unequivocally that the stock market views R&D expenditures as enhancing the value of firms, on average, and that investors also demonstrate some ability to differentiate the value of R&D across industries, firm sizes, and stage of R&D maturity.[23,24]

**Estimating R&D Capital (Cost Basis).** While R&D capital is the major asset of most high-tech and

17. (Griliches 1995)

18. The research using patent counts and citations as R&D output measures is voluminous, and is summarized in Griliches (1989) and Hall et al. (1998).

19. See, for example, Chan et al. 1992. It was widely believed in the 1980s and early 1990s that, prodded by investors' "obsession" with quarterly earnings, U.S. managers routinely sacrificed the long-term profitable growth of their firms by curtailing investments, such as R&D, with long payoffs but immediate hits to earnings. The evidence of investors' positive reaction to R&D increases, despite the negative effect of such increases on near-term earnings (due to the immediate expensing of R&D), largely dispels the allegation of investor myopia, at least with respect to R&D.

20. (Pinches et al. 1996)

21. (Ben-Zion 1978, Hirschey and Weygandt 1985, Bublitz and Ettredge 1989).

22. (Chauvin and Hirschey 1993)

23. Hall (1993a, 1993b) reports an intriguing finding that investors' valuation of R&D decreased substantially during the mid-to-late 1980s. This decrease, however, was found to be most evident in the electronics sector and has been largely reversed in the 1990s.

24. While investors as a group reward R&D expenditures, a recent study (Bushee 1998) found that institutions engaged in momentum trading (i.e., short-term oriented investors) tend to have large holdings in firms that "manage" earnings by cutting R&D to reverse earnings declines.

science-based companies, its value is nowhere to be found in financial reports. Obviously, the absence of a major asset from the book value (equity) or total assets of firms reduces the reliability and usefulness of conventional return-on-investment measures like ROE and ROA for performance evaluation. The assessment of companies' effectiveness in using investor capital requires that estimates of their investment in R&D be considered.

Economists often estimate the value of firms' R&D capital by assuming a uniform 10-15% annual amortization rate, which implies an amortization period, or average economic life, for R&D investment that ranges from roughly six to ten years. The assumed amortization rate is then used to "build up" a firm's R&D capital in cost terms. For example, based on a straight-line 15% annual amortization assumption, a firm's R&D capital at the end of a given year would be equal to 85% of its R&D expenditure in that year, plus 70% of R&D in the prior year, plus 55% of R&D expenditure in the year before that, and so on until a fully amortized R&D layer is reached.[25]

Since the pattern of R&D benefits varies across firms and industries, an industry- or firm-specific amortization rate is likely to do a better job of reflecting economic reality than a universal 10-15% rate. In a study published in 1996, Theodore Sougiannis and I estimated industry-specific R&D amortization rates using a (simultaneous equations) model that relates companies' operating profits to their tangible assets, advertising expenditures (proxying for brands), and the time series of their annual R&D expenditures extending back ten years.[26] The derived R&D lag structure allowed us to estimate the contribution to current profits of R&D expenditures made ten years ago, nine years ago, and so forth, ending with the contribution of current year's R&D to current profits. For example, in applying our model to pharmaceutical companies, our findings suggest that a dollar spent on R&D today increases future profits by $2.63, on average, and that the average life of R&D projects is 9 to 10 years.

The pattern of lagged contributions to future profits by R&D spending in turn allowed us to estimate firm-specific R&D capital for about 1,500 companies spanning a large variety of industries. In the case of Merck, for example, we found that an appropriate R&D-adjusted balance sheet would contain R&D capital with a value of some $3 billion at the end of 1991. This would represent a 60% addition to Merck's equity capital base.[27]

To examine the potential relevance of our estimates of R&D capital for investors, we used the estimates to calculate *capitalization-adjusted* earnings and book values and then ran a series of regressions to estimate the strength of the correlation of such *capitalization-adjusted* measures with stock prices and returns. Our regression analysis confirmed that the adjustments of both reported earnings and book values for the immediate expensing of R&D yield performance measures that are more strongly associated with market values than reported earnings and book values.

Firm-specific estimates of R&D capital, based either on a uniform (15%) amortization schedule or on industry-specific rates, could prove useful in the kind of corporate performance evaluation that relies heavily on financial ratio analysis.

**Estimating R&D Capital (Market Values).** Given the magnitude of corporate expenditures on R&D (over $150 billion in 1997) and ever-increasing demand for technology, one would expect *markets* for R&D to develop. Of course, markets for patent rights and the licensing of R&D have long been in operation. But recent years have witnessed a relatively new development—a large number of corporate acquisitions in the software, pharmaceutical, biotech, and electronics industries in which *R&D-in-process* was by far the major asset acquired. This became evident due to an accounting requirement ("purchase accounting" for acquisitions) that acquiring companies estimate separately the fair market value of the acquired assets, including R&D-in-process. In a recent study of such acquisitions, Zhen Deng and I found that the fair market values of acquired R&D (yet-to-be-completed R&D projects) amounted, on average, to 75% of the acquisition price.[28] Such acquisitions, numbering in the hundreds per year, are primarily trades in R&D and technology.

25. Sometimes a geometrically decaying R&D capital is assumed.

26. Lev and Sougiannis (1996). The rationale for estimating industry- rather than firm-specific amortization rates in our study was similar to that underlying the use of industry- rather than firm-specific beta values in cost of capital estimation. That is, the loss of specificity involved in an industry estimate is likely to be compensated for by reduction of noise in the industry data.

27. For a detailed example of the computation of firm-specific R&D capital for Merck & Co., see the appendix of the Lev and Sougiannis paper.

28. Deng and Lev (1998)

**In applying our model to pharmaceutical companies, our findings suggest that a dollar spent on R&D today increases future profits by $2.63, on average, and that the average life of R&D projects is 9-10 years.**

The fair market values assigned by management to acquired R&D-in-process are generally based on the present value of estimated cash flows from projects under development.[29] Our study finds that those fair values are closely associated with stock prices of acquiring firms, which in turn lends some credibility to management estimates. Moreover, a recent study of Australian companies reported that revaluations of intangibles (a procedure allowed in Australia but not in the U.S.) are significantly associated with stock prices, suggesting once more that investors pay attention to managers' assessments of market values of R&D.[30]

In addition to acquisitions where R&D is the prime asset acquired, another manifestation of developing markets for R&D are the "targeted stocks" issued in recent years by high-tech companies such as Alza and Genzyme. In those still small number of cases, the value of the security is derived from a specific R&D program or pool of patents transferred by the patent company to the new entity, thus representing a further step in the progressive securitization of intangibles.[31] In time, the prices observed in such markets will provide "comparables" or multiples for the purpose of intangibles' and enterprise valuations.

**Nonfinancial Indicators of R&D Value**. In search of reliable measures of R&D *output*, economists have experimented with various nonfinancial indicators, such as the number of patents registered by a company (patent counts), patent renewal and fee data, number of innovations, and citations of patents.[32] Patent counts and the number of innovations emerging from a company's R&D program have been found to be associated with both the level of corporate investment in R&D and with firms' market values. It is clear, however, that those R&D output measures are rather noisy due to the "skewness" of their value distributions—that is, the tendency of a few patents or innovations to generate substantial returns, while most turn out to be virtually worthless.[33] Citations (references) of a firm's patents included in subsequent patent applications ("forward citations") offer a more reliable measure of R&D value than the absolute number of patents, since such citations are an objective indicator of the impact of a firm's research activities on the subsequent development of science and technology.[34]

Various studies have shown that patent citations capture important aspects of R&D value. For example, Trajtenberg (1990) reports a positive association between citation counts and consumer welfare measures for CAT scanners; Shane (1993), in examining 11 semiconductor companies, finds that patent counts weighted by citations contribute to the explanation of cross-sectional differences in Tobin's q measures (market value over replacement cost of assets); and Hall et al. (1998) report that citation-weighted patent counts are associated with firms' market values (after controlling for the firms' R&D capital).[35]

In a direct test of the usefulness of patent citations to investors, Deng et al. (1999) and Hirschey et al. (1998) examine the ability of various measures derived from patent citations to *predict* subsequent stock returns and market-to-book (M/B) values in various R&D-intensive industries. The following three measures were all found to be significantly associated with future market-to-book values and stock returns of up to three years: (1) the number of patents granted to the firm in a given year; (2) the intensity of citations of a firm's patents in subsequent patents; and (3) a "science linkage" measure that reflects the number of citations in a firm's patents ("backward citations") of scientific papers and conferences (in contrast with citations of previous patents). The science linkage indicator is of special interest since it reflects the extent to which the firm engages in science-related or basic research as opposed to product development or process improvement. Furthermore, the predictive power of the science linkage measure with respect to stock performance is consistent with previously mentioned research that finds the contribution of basic research to firm productivity substantially larger than that of applied research aimed at product development.

29. See, for example, IBM's description in its 1995 annual report of the way it estimated Lotus' value of R&D-in-process ($1.84 billion).

30. Barth and Clinch (1998)

31. See Solt (1993) on R&D targeted securities and Beatty et al. (1995) on other R&D financing arrangements.

32. For a survey of this research, see Griliches (1989).

33. See, for example, Patel and Pavitt (1995).

34. The compilation of citations of previous patents or scientific studies in patent applications is of considerable importance and is checked carefully by patent examiners since patent citations assist in delineating the "claims," or property right boundaries, of the invention. Indeed, patent citations are used as evidence in patent infringement lawsuits. See Lanjouw and Schankerman (1997).

35. In two other studies, Austin (1993) reports that patents identifiable with end products tend to be more valued by investors than the average patent, and Megna and Klock (1993) find that patents of rival firms have a negative effect on a company's q-ratio.

As noted earlier, information about the nature of a company's R&D activities is generally not available in its financial statements. But, as the research just summarized suggests, non-financial indicators of R&D output such as number of patents, innovations, and trademarks—and in particular measures based on patent citations—offer a promising set of measures for firm valuation and security analysis.[36]

**Firms' Capitalization of R&D.** Software development costs are the major exception in the U.S. to the uniform expensing of R&D. FASB Statement No. 86 (enacted in 1985) requires companies to capitalize software development costs incurred after a project under development has reached technological feasibility (as generally evidenced by a working model or pilot).[37] The cumulative capitalized development cost (net of amortization) is presented as an asset on the balance sheet, while the periodic capitalized amount is subtracted from quarterly or annual development costs, which are then expensed in the income statement.

The amount of subjective judgment involved in the determination of technological feasibility of projects and the amortization of the capitalized asset led certain analysts and investment advisors to view software capitalization skeptically as detrimental to the quality of financial information. For example, the Association for Investment Management Research states: "We are not enamored of recording self-developed intangible assets unless their values are readily apparent; it usually is next to impossible to determine in any sensible or codifiable manner exactly which costs provide future benefit and which do not."[38]

But some recent empirical research suggests that the capitalization of intangibles may in fact provide useful information to investors. When David Aboody and I examined capitalization data disclosed during 1986-1995 by 168 software companies, we found that:

- annually capitalized software development costs (i.e., the part of the total development cost that is not expensed) are positively and significantly associated with stock returns;
- the value of the software asset that is reported on the balance sheet is reliably associated with stock prices; and
- software capitalization data improve the prediction of future earnings.[39]

Particularly intriguing, moreover, was our finding that software companies that consistently expensed all their development costs (about a third of the examined sample) experienced positive abnormal return *drifts* that persisted for at least three years after the cost expensing, while firms that capitalized development costs did not. This evidence is consistent with some undervaluation of the shares of fully expensing firms, attributable perhaps to the lack of timely information about the progress and success of their software development programs (information that could be partly disclosed by the capitalization process).[40]

The evidence thus suggests that despite the subjectivity involved in the capitalization of software development costs, this procedure provides useful information to investors. The extent to which this conclusion can be generalized to other types of R&D (e.g., drug development) awaits further research. Nevertheless, it is worth noting that a recent simulation study clearly demonstrates the superiority of intangibles' capitalization over expensing in providing meaningful earnings data to investors. The simulation model measures the performance of pharmaceutical companies under immediate expensing of R&D and alternatively under capitalization, and compares the performance measures with economic returns and values (based on future cash flows). The results show that capitalization-based performance measures explain twice the variation in value as expensing-based measures.[41]

**R&D and the Deteriorating Usefulness of Financial Information.** It is widely acknowledged that the accounting measurement and reporting system has failed to keep up with recent sweeping changes

36. Stephan (1998) reports that the number of scientific publications of scientists associated with biotech startups is positively correlated with the IPO prices of these companies.

37. FASB Statement No. 86 applies to software developed for *sale*. In March 1998, the Accounting Standards Executive Committee of the AICPA (AcSEC) issued a statement of position (SOP 98-1) which applies the main criteria of FASB Statement No. 86 to software developed for *internal use*.

38. (AIMR 1993, p.50)

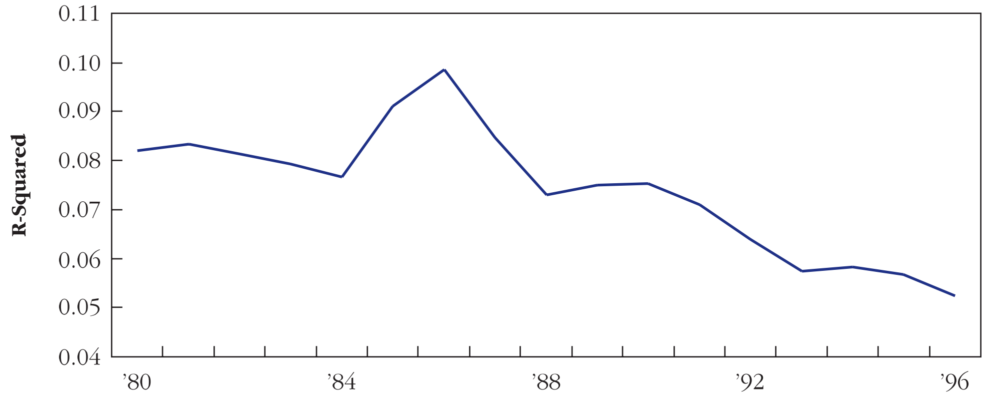
39. Aboody and Lev (1998). This predictive ability of capitalized values is consistent with the FASB's capitalization criterion—the establishment of technological feasibility. Projects achieving technological feasibility are more likely to generate higher earnings in the near future than earlier-stage projects, hence the association between the amounts capitalized and subsequent earnings.

40. The subsequent return drifts associated with full expensing software companies is consistent with a similar finding in Lev and Sougiannis (1996, section 6), indicating that the shares of firms intensive in R&D (which is fully expensed in the U.S.) are associated with subsequent positive returns, after controlling for various risk factors. Relatedly, Chan et al. (1998) report that poorly performing firms that continue to invest substantially in R&D are also characterized by subsequent positive abnormal returns, which is consistent with undervaluation.

41. Healy et al. (1998)

**The extent of the association between earnings and stock returns has continuously decreased over the past 20 years.**

**FIGURE 3** THE ASSOCIATION BETWEEN ANNUAL EARNINGS AND STOCK RETURNS




Source: Lev and Zarowin (1998, Table 1). The data are R-squared measures (3-year moving averages) from yearly regressions of annual returns on levels and changes of annual earnings.

in the economy. Such changes have been driven by the continuous restructuring of firms' operations and the extensive deregulation of important economic sectors (such as telecommunications), as well as by the innovation-producing activities of companies that are the focus of this paper. Various public committees that have examined the usefulness of financial information to investors report widespread concerns of financial statement users with both the timeliness and relevance of information conveyed by corporate reports.[42] The popularity of business performance measures like EVA, which makes potentially large adjustments to reported earnings, also attests to the dissatisfaction of users, both internal and external to the firm, with the product of the accounting measurement system.

In a recent study, Paul Zarowin and I examined changes in the usefulness of financial information by analyzing the association over the last 20 years between stock prices and returns, on the one hand, and key financial variables such as earnings, cash flows, and book values.[43] This research comes to the following conclusions:

- the extent of the association between stock returns (prices) and financial variables has continuously decreased over the examined period, as portrayed in Figure 3 for earnings and stock returns;
- the major culprit responsible for the deteriorating usefulness of financial information is *business change*, since the costs and benefits associated with change are mismatched in the computation of earnings;[44] and
- R&D, a major driver of change, is directly associated with the decreasing usefulness of earnings.

More specifically, our study finds that firms that increased their R&D intensity over the 1977-1997 period experienced an above-average *decrease* in the association between earnings and stock returns, while firms whose R&D intensity declined experienced an *increase* in the strength of their returns-earnings association.[45]

The capital market consequences of informationally deficient financial reports have yet to be fully established, but some recent studies suggest they could be significant. For example, Boone and Raman (1998) report that unexpected changes in R&D are associated with a widening of the bid-ask spreads of stocks (an expected market-maker reaction to an increase in information asymmetry), leading to increased investors' transaction costs and decreased stock liquidity. Barth et al. (1998) document an increased level of analysts' efforts and possible mispricing of securities associated with high levels of R&D intensity. Aboody and Lev (1998) find

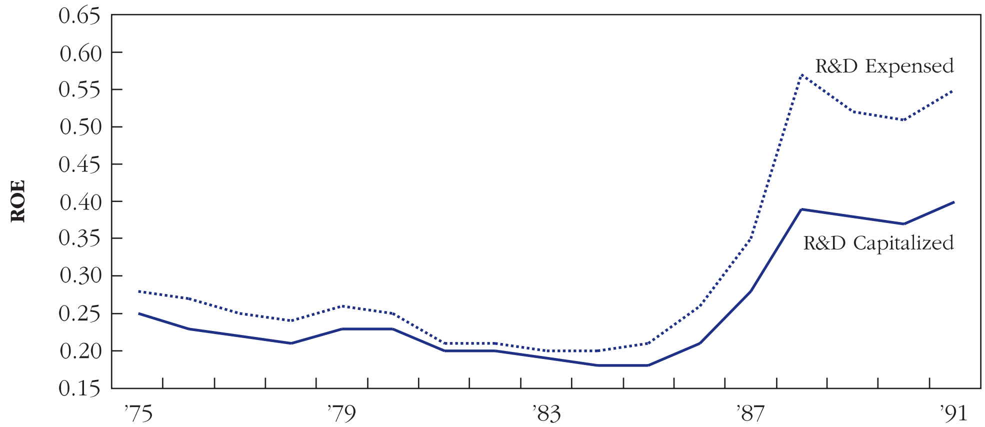
42. See, for example, AICPA (1993).

43. Lev and Zarowin (1998).

44. The costs associated with change (e.g., restructuring charges, R&D expenditures) are recognized immediately in the financial reports, while the benefits are reflected in future periods. Such a mismatching of costs and benefits adversely affects the informativeness of earnings and book values.

45. A mini-research industry has recently developed around the examination of temporal changes in the usefulness of financial information. Essentially all studies document a decrease in the returns-earnings association. On the other hand, Collins et al. (1997) report that the decrease in the returns-earnings association was compensated for by an increase in the stock price-book value association. Chang (1997) corroborates the Lev and Zarowin (1998) findings of a temporal decrease in the informativeness of both earnings and book values.

**FIGURE 4**
MERCK & CO.: RETURN ON EQUITY (ROE) BASED ON EXPENSING AND CAPITALIZATION OF R&D




Source: Lev and Sougiannis (1996, Appendix).

that officers of R&D-intensive firms gain from insider trading significantly more than their counterparts in firms not engaged in R&D. And Lev and Sougiannis (1996), Aboody and Lev (1998), Chan et al. (1998), and Lev et al. (1999) all report evidence consistent with mispricing (generally undervaluation) of the shares of R&D-intensive companies. Finally, there is also evidence that some firms "manage" their reported earnings—say, by cutting R&D in response to shortfalls in operating earnings—which further compounds the information problems confronting investors in high-tech companies.[46]

In sum, the preliminary evidence suggests that the information and reporting deficiencies related to R&D activities have various adverse capital market consequences, which in turn may reduce firms' value by increasing monitoring costs and the cost of capital.[47]

## OPERATING INSTRUCTIONS

What inferences can capital market practitioners draw from the empirical research on corporate R&D? I will classify such inferences, or "operating instructions," into two themes: (1) those that can be applied to the on-going performance evaluation of firms and (2) those useful for special purpose assignments, such as valuations for IPO pricing and corporate control transactions such as acquisitions and divestitures.

### Performance Evaluation

Financial statements of R&D-intensive companies fail to provide adequate information for the assessment of profitability, growth, and enterprise risk. Contrary to widespread beliefs, the immediate expensing of intangible investments—including expenditures on brand maintenance and human resources as well as R&D—is not even necessarily a conservative practice. In fact, for firms with relatively low growth rates of intangibles—that is, the typical mature company—the immediate expensing of intangibles leads to a substantial *overstatement* of reported profitability.[48] In such cases, the effect of excluding intangible capital from the denominator of profitability ratios like ROE and ROA far outweighs the increased earnings under capitalization.[49] For example, as shown in Figure 4, the reported ROE (with immediate expensing of R&D) of Merck & Co.

46. See, for example, Baber et al. (1991).

47. In a similar vein, Bronwyn Hall (1993a p.290) comments: "asymmetric information between firms and investors implies that, to fund [R&D] projects about which they do not have full information, investors will demand a 'lemons' premium in the form of a higher rate of return." Obviously, in assessing the desirability of increased disclosure about firms' R&D activities, the competitive harm to firms from such disclosure and its effect on incentives to engage in R&D should be considered.

48. The exact relationship between ROE (ROA) under expensing and capitalization of intangibles is as follows: When the firm's growth rate of intangible investment is higher than its return on equity (which is typical of young firms and industries), ROE (ROA) under expensing will be lower than under capitalization. But ROE and ROA under expensing will be higher for firms whose growth rate of intangibles is lower than their return on equity. For details, see Lev et al. (1999).

49. Under intangibles' expensing, earnings are charged with the periodic R&D expenditure, while under capitalization the amortization of the R&D capital (asset) is subtracted from earnings. For firms with a low growth rate of R&D, the difference between R&D expenditure and amortization will be relatively small, leaving the numerator of ROE (ROA) little changed, while the denominator is highly understated due to the absence of the intangible capital.

**Financial analysts can partly correct for the reporting biases and distortions of R&D by capitalizing and amortizing both internal and acquired R&D. This adjustment involves adding back the expensed R&D (net of amortization) to earnings and total capital.**

in the late '80s and early '90s was around 50-55%; but if Merck had instead capitalized and amortized its R&D, its ROE in that period would have ranged from 35-40%.[50]

Moreover, in a recent study, Bharat Sarath, Theodore Sougiannis, and I analyzed the impact of R&D expensing on reported earnings *growth*, which is the primary focus of many investors.[51] Our study demonstrated that firms whose growth rate of R&D falls below their growth in earnings will report higher earnings momentum when R&D is fully expensed than when R&D is capitalized and amortized. Thus, in this case as well—typical of mature companies—the expensing of R&D is far from conservative.

These biases in the reported performance of R&D-intensive companies are aggravated by the fact that U.S. firms expense not only *internally generated* R&D, but also *acquired* R&D. As noted earlier, acquired R&D amounts to 75%, on average, of the total acquisition price in those deals in which it is involved.[52] Obviously, the immediate expensing of the lion's share of the acquisition price substantially inflates the reported profitability of acquiring firms in the years after the acquisition. Post-acquisition earnings from the acquired entity are unencumbered by the previously expensed R&D, and the reported total assets or equity of the acquiring company reflects only a small portion of the total investment in the acquired entity. Thus, the full-expensing of R&D, internal as well as acquired, tends to inflate the reported profitability of R&D-intensive enterprises as well as the rate of growth of their reported earnings.

Financial analysts can partly correct for the reporting biases and distortions discussed above by a systematic reversal of R&D expensing—that is, by capitalizing and amortizing both internal and acquired R&D.[53] This adjustment involves adding back to earnings the expensed R&D and subtracting from earnings the amortization of the capitalized R&D. On the balance sheet, the R&D capital (net of amortization) should be added to total assets and equity (book value).[54]

To perform such a capitalization adjustment, the value of acquired R&D, which is provided in financial statement footnotes, should first be added to assets and equity. In contrast, the capitalized value of internal R&D has to be estimated. The key to the capitalization and amortization of internal R&D is the assumed *amortization rate*, or *average expected life*, of R&D projects, which is not reported by firms. As mentioned earlier, in estimating firms' R&D capital economists often use uniform annual amortization rates that range between 10% and 15%. But it is obviously preferable, whenever possible, to use industry- or firm-specific rates that reflect differences in technology and the appropriability of R&D benefits (relatively high in chemicals and drugs, where R&D is effectively protected by patents, and low in software and instruments) across industries and companies. Using the industry-specific amortization rates estimated by Lev and Sougiannis (1996) and other sources,[55] the following annual amortization rates seem suitable for R&D capitalization in the process of financial analysis:

- 8-10% (or amortization periods of 10-12 years) for pharmaceutical companies;
- 12-15% (6-8 years) for chemicals;
- 17-20% (5-6 years) for computer hardware, electronic equipment, and transportation vehicles; and
- 25% (4 years) for scientific instruments and software.

Despite the coarseness of the proposed capitalization and amortization estimates, it is inconceivable that investment analysis based on the uniform 100% amortization of R&D that now underlies reported earnings and book values could not be improved by the adjustment procedure outlined above.[56] Furthermore, the proposed capitalization procedure overcomes a disturbing inconsistency in accounting practices related to internally developed vs. acquired R&D products (e.g., scientific instruments). When a company acquires such a product it is recorded as an asset, whereas when the product is internally developed, all or most of the development costs are

50. Among the reasons for the increasing divergence between Merck's ROE (expensing) and ROE (capitalization) in the late 1980s (see Figure 4) is the considerable slowdown in its R&D growth. While Merck's average annual growth rate of R&D between 1977 and 1987 was close to 30%, its average annual R&D growth from 1987 to 1991 decreased to 18.6%. Ceteris paribus, the lower the growth rate of R&D, the larger the overstatement of reported profitability relative to profitability based on the capitalization of intangibles.

51. (Lev et al.1999).

52. (Deng and Lev 1998); sample period ended in 1997.

53. Note that the EVA performance evaluation system also reverses the immediate expensing of intangibles.

54. For firms whose R&D expenditures are stationary (zero growth), capitalization will not affect earnings (in a steady state), but will affect book value and total assets. For all other firms, the proposed capitalization will affect both earnings and book values. For details of the capitalization procedure, see Lev and Sougiannis (1996, Appendix).

55. See, for example, Deloitte & Touche 1996 annual survey of the software industry.

56. This conclusion is also supported by (Chambers et al. 1997), which shows that the explanatory power of earnings and book values with respect to stock prices increases when the financial variables are adjusted to reflect the capitalization of R&D.

expensed. The comparability of financial information between purchasing and developing companies can be restored by capitalizing the development costs of the latter companies.

Finally, it should be noted that the capitalization procedure outlined above is no substitute for the procedure for capitalizing intangibles that is currently required for software companies. Because such capitalization begins only after projects under development pass a technological feasibility test, the capitalization data provide investors with important information about the progress and probable success of firms' development programs. Furthermore, the writeoff of capitalized assets that are no longer commercially viable provides additional important information to investors. Such information, needless to say, is not reflected in the mechanical capitalization procedure proposed above.

### In-Depth Assessment of Innovative Capabilities

The valuation and due diligence of R&D-intensive enterprises performed for corporate control transactions or IPOs require a thorough understanding and assessment of the innovative capabilities of the examined enterprise and its capacity to produce and market the developed products. Such assessment should begin with an analysis of the enterprise's R&D *strategy*—an analysis that determines the extent to which the firm primarily *develops* products and services, *shares* development with others through alliances, or *acquires* R&D. The strategy analysis should then attempt to ascertain the proportions of resources devoted to basic research vs. product development and cost reduction ("process R&D"), and to an assessment of the firm's capability to *use* rather than to *perform* R&D—that is, its record of learning from other companies' (and universities') innovations and adapting quickly to external technological changes. Learning from others requires an adequate scientific and engineering capacity as well as flexibility of organizational design. An examination of an enterprise's research strategy and capabilities will also shed light on the riskiness of investment in R&D. Obviously, the heavier the investment in basic vs. applied research, and the larger the proportion of inhouse R&D vs. that developed in alliance with other firms, the riskier are the firm's R&D activities.

Research capability should be assessed primarily by *output* measures, such as the number of new products that have emerged from the development process, as well as the number of patents, patent citations, and trademarks registered (as discussed earlier, each of these measures of R&D output have been demonstrated to have a strong positive correlation with stock-price performance). Most important, efforts should be made to quantify the contribution of R&D activities to sales, cost savings, and earnings. Various quantitative measures can be used to gauge research output, such as citations to the firm's patents and measures indicating the share of current revenues coming from products developed within the last three or five years. The latter measure indicates the firm's ability to quickly "bring products to the market," a capacity which often differs from the ability to develop products.

R&D strategy should be evaluated in the context of the firm's overall strategic position. Is the firm an industry leader, reaping the advantages of a "first mover"; or is it a "follower" in introducing new products and innovations? What is the firm's record in appropriating the benefits of its innovative activities, such as successfully defending its patents from infringement and maximizing licensing revenues? Answers to these and similar questions will shed light on the firm's innovative capabilities.

Finally, the firm's product *pipeline* has to be considered. Even when accompanied by an impressive historical record of developing and marketing products, an impoverished pipeline of projects does not bode well for the future. This calls for a thorough examination of products under development, such as drugs in FDA approval process, as well as patents and trademarks pending registration. Also to be examined are current and expected revenues from licensing agreements and the activity level of research and development performed within alliances and joint ventures. When *valuation* of R&D-in-process is required (as in the case of corporate acquisitions), the future cash flows from pipeline projects should be estimated, accounting among other things for synergies with the acquiring entity's R&D. Such cash flow-based valuations of R&D-in-process are now common, given the large volume of technology company acquisitions.

An assessment of firms' product development and marketing capacity should also take into consideration managers' incentives to "manage" reported performance. As mentioned earlier, research indicates that under certain circumstances managers will change periodic R&D expenditures to

**Efforts should be made to quantify the contribution of R&D activities to sales cost savings, and earnings. Various quantitative measures can be used to gauge research output, such as citations of the firm's patents and measures indicating the share of current revenues coming from products developed within the last three or five years.**

achieve earnings targets or conform with investors' expectations.[57] Such "management" of R&D and the resulting effect on reported earnings should be adjusted for in the evaluation of R&D capabilities and consequences.[58]

## SUMMARY

Although R&D is the major productive factor and the principal asset of high-tech and science-based companies, public information about firms' R&D activities and their benefits is wholly inadequate for investment research and analysis. This paper begins with a brief review of statistics that show the growth of U.S. corporate R&D expenditures outstripping the growth of corporate investment in tangible assets. Next, in comparing R&D disclosure regulations among industrialized nations, I show that U.S. rules are the least flexible in allowing management discretion in the measurement and reporting of R&D (e.g., capitalization vs. expensing). Then I survey the large and growing body of empirical research on R&D, which demonstrates unequivocally that (1) the contribution of R&D to productivity and shareholder value is substantial and (2) that capital markets reflect such contributions in stock prices. But if investors clearly demonstrate a willingness to take the "long view" of R&D in many cases, there is also some evidence of undervaluation of R&D-intensive companies as well as other potential costs to some corporations and investors stemming from inadequate public information about R&D. In the final section, I offer some operating guidelines for investors and analysts that follow R&D-intensive companies, suggesting a number of adjustments of financial data (in particular, capitalizing instead of expensing some forms of R&D) designed to better reflect corporate performance and value.

57. See, for example, Perry and Grinaker (994), Baber et al. (1991), Bushee (1998).

58. Incentive compensation plans, such as EVA, that capitalize R&D expenditures reduce but do not eliminate incentives to manage earnings via R&D.

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